CLAIMS

What is claimed is:

1. A method for controlling movement of a member wherein the angle of the member with respect to a reference is alterable by a first actuator and the length of the member is alterable by a second actuator, the method comprises:

producing a command which designates a desired velocity that a point on the member is to travel along a desired substantially straight line path;

transforming the command into a desired first velocity for the first actuator;

transforming the command into a desired second velocity for the second actuator;

operating the first actuator in response to the desired first velocity to alter the angle of the member; and

operating the second actuator based on the desired length velocity to alter the length of the member.

2. The method as recited in claim 1 wherein producing a command comprises designating a first desired velocity that the point on the member is to travel along a first axis.

3. The method as recited in claim 1 wherein producing a command comprises:

designating a first desired velocity that the point on the member is to travel along a first axis; and

designating a second desired velocity that the point on the member is to travel along a second axis that is orthogonal to the first axis.

4. The control system as recited in claim 1 wherein transforming the command into a desired first velocity for the first actuator comprises:

transforming the command into a desired angular velocity for the member; and converting the desired angular velocity into the desired first velocity.

5. A method for controlling movement of a member wherein the angle of the member with respect to a reference is alterable by a first actuator and the length of the member is alterable by a second actuator, the method comprises:

producing a command which designates a desired velocity that a point on the member is to travel along a desired substantially straight line path;

transforming the command into a desired angular velocity and a desired length velocity for the member;

converting the desired angular velocity for the member into a desired first velocity for the first actuator;

operating the first actuator in response to the desired first velocity to alter the angle of the member; and

operating the second actuator based on the desired length velocity to alter the length of the member.

6. The method as recited in claim 5 wherein producing a command comprises designating a first desired velocity that the point on the member is to travel along a first axis.

7. The method as recited in claim 5 wherein producing a command comprises:

designating a first desired velocity that the point on the member is to travel along a first axis; and

designating a second desired velocity that the point on the member is to travel along a second axis that is orthogonal to the first axis.

8. The method as recited in claim 7 wherein transforming the command utilizes the relationships defined by the equations:

$$\dot{X} = \cos(\theta + \gamma)\,\dot{L} + (-L\sin(\theta + \gamma) + d\cos(\theta + \gamma))\,(\dot{\theta} + \dot{\gamma})$$

$$Y = \sin(\theta + \gamma)\,\dot{L} + (L\cos(\theta + \gamma) + d\sin(\theta + \gamma))\,(\dot{\theta} + \dot{\gamma})$$

where $\dot{X}$ is velocity of the point on the member along the first axis, $\dot{Y}$ is velocity of the point on the member along the second axis, θ is the angle of the member, $\dot{\theta}$ is the angular velocity of the member, γ is the pitch angle of a machine on which the member is mounted, L is the length of the member, $\dot{L}$ is the rate at which the length of the member is changing, and d is a distance that the point is offset from a longitudinal axis of the member.

9. The method as recited in claim 5 wherein transforming the command utilizes the angular position of the member which is derived by sensing a dimension of the first actuator and converting that position into the angular position of the member.

10. The method as recited in claim 5 wherein transforming the command utilizes the length of the member which is derived by sensing a dimension of the second actuator and converting that dimension into the length of the member.

11. The method as recited in claim 5 further comprising converting the desired length velocity for the member into a second velocity for the second actuator, wherein operating the second actuator is in response to the second velocity.

12. The method as recited in claim 5 further comprising:

sensing a first parameter of the machine to produce a first signal denoting the angle of the member relative to a reference;

sensing a second parameter of the machine to produce a second signal denoting the length of the member;

deriving an actual angular velocity of the member from the first signal; and

deriving an actual length velocity of the member from the second signal.

13. The method as recited in claim 12 further comprising:

generating first error value corresponding to a difference between the actual angular velocity and the desired angular velocity;

generating second error value corresponding to a difference between the actual length velocity and the desired length velocity;

adjusting the desired angular velocity in response to the first error value to produce a corrected desired angular velocity which is employed in operating the first actuator; and

adjusting the desired length velocity in response to the second error value to produce a corrected desired length velocity which is employed in operating the second actuator.

14. The method as recited in claim 13 wherein generating first error value and generating first error value both utilize a proportional-integral-derivative control function.

15. The method as recited in claim 12 wherein sensing a first parameter senses a dimension of the first actuator.

16. The method as recited in claim 12 wherein sensing a first parameter senses the angle of the member relative to a reference.

17. The method as recited in claim 12 wherein sensing a second parameter of the machine senses a dimension of the second actuator.

18. The method as recited in claim 5 further comprising:

sensing a first parameter of the first actuator;

sensing a second parameter of the second actuator;

in response to the first parameter, deriving an actual velocity of the first actuator;

in response to the second in response to the second parameter, deriving an actual velocity of the second actuator;

generating a first error value corresponding to a difference between the actual velocity of the first actuator and the desired first velocity;

generating a second error value corresponding to a difference between the actual velocity of the second actuator and the desired second velocity;

adjusting the desired first velocity in response to the first error value to produce a result which is used in operating the first actuator; and

adjusting the desired second velocity in response to the second error value to produce another result which is used in operating the second actuator.

19. The method as recited in claim 18 wherein generating a first error value and generating a second error value both utilize a proportional-integral-derivative control function.

20. A method for controlling movement of a member, wherein an angle of the member with respect to a reference is alterable by a first actuator and the member has a first section that extends from a second section by an amount that is varied by a second actuator, the method comprises:

designating a first desired velocity that a point on the member is to travel along a first axis;

designating a second desired velocity that a point on the member is to travel along a second axis which is orthogonal to the first axis;

sensing a first parameter of the first actuator;

deriving an angular position of the member from the first parameter;

sensing a second parameter that indicates an amount that the first section extends from the second section;

deriving the length of the member from the second parameter;

transforming the first and second desired velocities into a desired angular velocity and a desired length velocity for the member, wherein that transforming is based on the angular position and the length of the member;

converting the desired angular velocity for the member into a desired first velocity for the first actuator;

operating the first actuator in response to the desired first velocity to alter the angle of the member; and

operating the second actuator based on the desired length velocity to alter the length of the member.

21. The method as recited in claim 20 wherein sensing a second parameter comprises sensing a dimension of the second actuator.

22. The method as recited in claim 20 wherein converting the desired angular velocity comprises:

deriving an actual angular velocity of the member from the first parameter;

generating first error value corresponding to a difference between the actual angular velocity and the desired angular velocity; and

adjusting the desired angular velocity in response to the first error value to produce a corrected desired angular velocity which is employed in operating the first actuator.

23. The method as recited in claim 20 wherein operating the second actuator comprises converting the desired length velocity for the member into a desired second velocity for the second actuator.

24. The method as recited in claim 23 wherein converting the desired length velocity comprises:

deriving an actual length velocity of the member from the second parameter;

generating second error value corresponding to a difference between the actual length velocity and the desired length velocity; and

adjusting the desired length velocity in response to the second error value to produce a corrected desired length velocity which is employed in operating the second actuator.

25. A control system for a member which is movable by first and second actuators that respectively control the angle of the member relative to a reference and the length of the member, the control system comprising:

an input apparatus that produces a command designating a desired velocity of a point on the member along a desired substantially straight line path;

a transformation function coupled to the input apparatus and converting the command into an angular velocity and a length velocity for the member;

a first converter which translates the angular velocity for the member into a first velocity at which the first actuator is to move;

a first driver for operating the first actuator in response to the first velocity to alter the angle of the member; and

a control element for operating the second actuator in response to the length velocity to alter the length of the member.

26. The method as recited in claim 25 wherein command produced by the input apparatus designates a first desired velocity along a first axis and a second desired velocity along a second axis that is substantially orthogonal to the first axis.

27. The control system as recited in claim 25 wherein the control element comprises:

a second converter which translates the length velocity for the member into a second velocity at which the second actuator is to move; and

a second driver for operating the second actuator in response to the second velocity to alter the length of the member.

28. The control system as recited in claim 25 further comprising:

a first sensor that produces a first signal indicating a first parameter of the machine which denotes the angle of the member relative to a reference;

a second sensor producing a second signal that denotes the length of the member;

a first differentiator that derives an actual angular velocity of the member from the first signal;

a second differentiator that derives an actual length velocity of the member from the second signal;

an angle controller which generates first error value corresponding to a difference between the actual angular velocity and the desired angular velocity;

an length controller which generates second error value corresponding to a difference between the actual length velocity and the desired length velocity;

a first adjusting element that alters the desired angular velocity in response to the first error value to produce a corrected desired angular velocity which is applied to the first converter; and

a second adjusting element that alters the desired length velocity in response to the second error value to produce a corrected desired length velocity which is employed by the control element in operating the second actuator.